



# NASA Procedural Requirements

**COMPLIANCE IS MANDATORY**

**NPR 8715.5A**

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## Range Flight Safety Program

**Responsible Office: Office of Safety and Mission Assurance**

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# Preface

## P.1 Purpose

This NASA Procedural Requirements (NPR) document defines the Agency Range Flight Safety Program. This NPR provides for implementation of NASA Policy Directive 8700.1, NASA Policy for Safety and Mission Success regarding the protection of the public, workforce, and property during range operations associated with flight (see Appendix A of this NPR for detailed definitions for “public,” “property,” “range operation,” and “flight”). Throughout this document, the term “range safety” is used with regard to range flight safety. This NPR describes NASA’s range flight safety policy, roles and responsibilities, requirements, and procedures. Chapter 3 of this NPR incorporates NASA’s public risk acceptability policy for range operations associated with flight.

## P.2 Applicability

P.2.1 This NPR contains requirements that apply to the following:

- a. NASA Headquarters, NASA Centers and Component Facilities, the Jet Propulsion Laboratory, and NASA contractors, as provided for in their contracts, when these organizations conduct or participate in missions that involve range operations as defined by this NPR.
- b. NASA range operations involving space launch vehicles, entry vehicles (including sample return capsules), reusable launch vehicles (RLVs), fly-back boosters, expendable launch vehicles (ELVs), high altitude balloons, sounding rockets, drones, and unmanned aircraft systems (UAS).
- c. NASA vehicle programs that use a range, launch site, or landing site to support their flight missions, including NASA, Department of Defense (DoD), commercial, foreign, or temporary ranges (e.g., Wallops Flight Facility, White Sands Missile Range, Kennedy Space Center (KSC), Eastern Range, Western Range, Reagan Test Site, Kodiak Launch Complex). For simplicity throughout this document, “program” includes any program, project, or acquisition.

*Note: NASA range operations are subject to this NPR and any local range requirements (e.g., NASA launches at an Air Force range are subject to this NPR and Air Force Space Command Manual (AFSPCMAN) 91-710). The NASA Range Flight Safety Program actively participates with the national range safety community to ensure that NASA requirements remain consistent with the national consensus. In general, range safety requirements at United States Government ranges meet or exceed the requirements in this NPR. The Range Safety Tailoring Process defined in paragraph 1.4 of this NPR provides the mechanism for determining the complete set of NASA and local requirements that apply to a NASA range operation.*

- d. United States commercial space vehicles and foreign space vehicles when carrying a NASA payload and/or NASA astronauts and the operation is not conducted under a Federal Aviation Administration (FAA) commercial launch operator license or foreign government range/public safety authority. This NPR does not apply if a range operation is conducted under an FAA license or under foreign government range/public safety authority unless specified by the applicable contract or agreement (see paragraphs 2.2 and 2.4 of this NPR).

P.2.2 This NPR provides technical and procedural range safety requirements for flight, which represent only a portion of the requirements applicable to NASA programs involved in range operations.

P.2.2.1 This NPR does not contain ground safety requirements and does not apply to the processing of a vehicle or payload at a range, launch site, or landing site. NASA vehicles and payloads are subject to the local ground safety requirements and other specific Agency and program requirements. For example, NPR 8715.7, Expendable Launch Vehicle Payload Safety Program, defines NASA's ELV payload safety review process and requirements.

P.2.2.2 This NPR does not apply to on-orbit operations that take place after orbital insertion and prior to final commitment to entry and landing. NPR 8715.6, NASA Procedural Requirements for Limiting Orbital Debris, applies to on-orbit operations.

P.2.2.3 This NPR does not address safety concerns associated with orbital debris. NPR 8715.6 contains requirements for limiting orbital debris generation, including requirements that apply to the disposal of spent launch vehicle upper stages after orbital insertion and orbital spacecraft that have completed their mission.

P.2.2.4 This NPR does not provide for the safety of any crew on board a vehicle during flight. Some requirements in this NPR account for the presence of a flight crew so as to not unnecessarily increase risk to the flight crew. NPR 8705.2, Human-Rating Requirements for Space Systems, addresses crew safety. NPR 7900.3, Aircraft Operations Management, addresses aircraft crew safety and applies to any aircraft involved in a range operation.

P.2.2.5 This NPR does not apply to the transportation or shipping of a vehicle or payload to or from a range, launch site, or landing site when this activity is not part of a range operation. Federal, State, and local regulations apply. NASA STD 8719.12, Safety Standard for Explosives, Propellants, and Pyrotechnics, provides information concerning the transportation of any vehicle or payload containing explosives, propellants, or pyrotechnics.

P.2.2.6 This NPR does not contain mission assurance requirements. The following apply with regard to mission assurance for launch vehicles and spacecraft: NPD 8700.3, Safety and Mission Assurance (SMA) Policy for NASA Spacecraft, Instruments, and Launch Services and NASA STD 8709.2, NASA Safety and Mission Assurance Roles and Responsibilities for Expendable Launch Vehicle Services.

P.2.2.7 This NPR does not contain requirements for environmental protection. NPR 8580.1, Implementing the National Environmental Policy Act and Executive Order 12114, applies with regard to environmental protection during range operations.

P.2.2.8 This NPR does not apply to conventional piloted aircraft unless a specific aspect of an operation requires range safety involvement to protect the public, workforce, and/or property. This NPR does not apply to inhabited or uninhabited ground or underwater vehicles.

P.2.2.9 This NPR does not apply with regard to potential acts of terror during a range operation. NPR 8715.2, NASA Emergency Preparedness Procedural Requirements, takes precedence with regard to such potential cases.

P.2.3 Existing programs that have completed the range safety tailoring process (see paragraph 1.4 of this NPR) using the previous version of this NPR and prior to the issue date of this version need not modify their program-specific range safety requirements to reflect this version and may continue working to their approved tailored range safety requirements.

*Note: The significant changes associated with this version of this NPR provide programs with clarification and added flexibility. There are no critical safety concerns being addressed by specific changes in this version of this NPR. Existing programs may elect to update their tailored range safety requirements to incorporate this version of this NPR.*

P 2.4 NM 8715-79, Granting Relief from Agency-level Safety and Mission Assurance Requirements, does not apply to the requirements of this NPR. The processes for granting relief from NASA range safety requirements are covered in paragraphs 1.4, 1.5, and 1.6 of this NPR.

## **P.3 Authority**

42 U.S.C. 2473(c)(1), Section 203(c)(1) of the National Aeronautics and Space Act of 1958, as amended.

## **P.4 Applicable Documents**

- a. 14 CFR 101: Aeronautics and Space, Part 101 - Moored Balloons, Kites, Unmanned Rockets and Unmanned Free Balloons.
- b. 14 CFR Aeronautics and Space, Parts 400-1199, Commercial Space Transportation, Federal Aviation Administration, Department of Transportation.
- c. 29 CFR 1910.1200, Hazard Communication.
- d. NPD 1050.1, Authority to Enter Into Space Act Agreements.
- e. NPD 1360.2, Initiation and Development of International Cooperation in Space and Aeronautics Programs.
- f. NPD 1371.5, Coordination and Authorization of Access by Foreign Nationals and Foreign Representatives to NASA.
- g. NPD 1800.2, NASA Occupational Health Program.
- h. NPD 8700.1, NASA Policy for Safety and Mission Success.
- i. NPD 8700.3, Safety and Mission Assurance (SMA) Policy for NASA Spacecraft, Instruments, and Launch Services.
- j. NPD 8710.1, Emergency Preparedness Program.
- k. NPR 1371.2, Procedural Requirements for Processing Requests for Access to NASA Installations or Facilities by Foreign Nationals or U.S. Citizens Who are Representatives of Foreign Entities.
- l. NPR 1800.1, NASA Occupational Health Program Procedures.
- m. NPR 2810.1, Security of Information Technology.
- n. NPR 7120.5, NASA Space Flight Program and Project Management Requirements.
- o. NPR 7150.2, NASA Software Engineering Requirements.
- p. NPR 7900.3, Aircraft Operations Management.
- q. NPR 8000.4, Agency Risk Management Procedural Requirements.
- r. NPR 8580.1, Implementing The National Environmental Policy Act And Executive Order 12114.
- s. NPR 8621.1, NASA Procedural Requirements for Mishap and Close Call Reporting, Investigating, and Recordkeeping.

- t. NPR 8705.2, Human-Rating Requirements for Space Systems.
- u. NPR 8705.6, Safety and Mission Assurance Audits, Reviews, and Assessments.
- v. NPR 8715.2, NASA Emergency Preparedness Plan Procedural Requirements.
- w. NPR 8715.3, NASA General Safety Program Requirements.
- x. NM 8715-79, Granting Relief from Agency-level Safety and Mission Assurance Requirements.
- y. NPR 8715.6, NASA Procedural Requirements for Limiting Orbital Debris.
- z. NPR 8715.7, Expendable Launch Vehicle Payload Safety Program.
- aa. NASA STD 8709.2, NASA Safety and Mission Assurance Roles and Responsibilities for Expendable Launch Vehicle Services.
- ab. NASA STD 8719.12, Safety Standard for Explosives, Propellants, and Pyrotechnics.
- ac. NASA STD 8719.13, Software Safety Standard.
- ad. RCC 319, Range Commanders Council Flight Termination Systems Commonality Standard.
- ae. RCC 321, Range Commanders Council Common Risk Criteria for National Test Ranges.
- af. RCC 323, Range Commanders Council Range Safety Criteria for Unmanned Air Vehicles.
- ag. RCC 555, User Guide for Unmanned Aerial Systems Operations on National Ranges.
- ah. The American Industrial Hygiene Association - Emergency Response Planning Guidelines.
- ai. Abbreviated Injury Scale (AIS), Association for the Advancement of Automotive Medicine.
- aj. Air Force Instruction (AFI) 91-217, Space Safety and Mishap Prevention Program.
- ak. Air Force Space Command Manual (AFSPCMAN) 91-710, Range Safety User Requirements Manual.
- al. Eastern and Western Range (EWR) 127-1, Range Safety Requirements.

## **P.5 Measurement/Verification**

Compliance with the requirements contained in this NPR will be verified through processes contained in NPR 8705.6, Safety and Mission Assurance Audits, Reviews, and Assessments.

## **P.6 Cancellation**

NPR 8715.5, Range Safety Program, dated July 8, 2005.

/S/

Bryan O'Connor  
Chief, Safety and Mission Assurance



# Chapter 1. Program Overview

## 1.1 Introduction

NASA operates and uses ranges for the purpose of launching, flying, landing, and testing space and aeronautical vehicles and associated technologies. These activities, referred to in this NPR as “range operations,” often present hazards which can pose significant risk to life and property. (See Appendix A for a detailed definition of “range operations.”) This NPR defines the Agency Range Flight Safety Program for protecting the public, the workforce, and property during range operations associated with flight.

## 1.2 Range Flight Safety Policy

1.2.1 It is NASA policy to mitigate and control hazards and risks associated with range operations in accordance with the requirements contained in this NPR.

1.2.2 It is NASA policy to apply range safety techniques to range flight operations in the following order of precedence:

a. Apply containment to preclude hazards (such as debris, distant focusing overpressure, and toxic material release resulting from planned and unplanned events) from reaching the public, the workforce, or property that requires protection.

*Note: Containment for the purposes of range safety is defined in Appendix A, and related requirements are in paragraph 3.2.9 of this NPR. Local authorities and programs are responsible for identifying property that requires protection per paragraph 3.2.4.3.b of this NPR.*

b. Apply the risk management process of paragraph 3.2.4 of this NPR when the hazards associated with a range operation cannot be fully contained.

## 1.3 Roles and Responsibilities

*Note: The NASA Administrator and senior Agency management roles and responsibilities regarding risk acceptance, including public risk acceptance, are described in NPD 8700.1, NASA Policy for Safety and Mission Success and apply to NASA range operations.*

1.3.1 NASA Chief, Safety and Mission Assurance. The NASA Chief, Safety and Mission Assurance or NASA designee shall:

a. Approve and promulgate Agency-level range safety policies and requirements (Requirement).

b. Oversee and provide funding for administration of the Agency Range Flight Safety Program (Requirement).

c. Formally designate the NASA Range Safety Manager (see paragraph 1.3.2 of this NPR) (Requirement).

d. Resolve any conflicts associated with the Agency Range Flight Safety Program that have not been resolved at the program or Center level (Requirement).

1.3.2 NASA Range Safety Manager. The NASA Range Safety Manager shall perform the following

## Headquarters-level functions:

- a. Develop, coordinate, and update Agency range safety policy, including this NPR (Requirement).

*Note: As a minimum, the NASA Range Safety Manager will lead the review and update of this NPR on the general five-year cycle. The Chief, Safety and Mission Assurance will determine the need for any interim updates.*

- b. Serve as the Agency focal point for all matters involving range safety (Requirement).
- c. Lead a team of Range Safety Representatives (see paragraph 1.3.5) to evaluate and resolve range safety program concerns and ensure consistent implementation of range safety requirements throughout the Agency (Requirement).
- d. Participate as an element of the NASA Headquarters Safety and Mission Assurance Audits, Reviews, and Assessments program defined by NPR 8705.6 and support Inter-center Aircraft Operations Panel reviews as defined by NPR 7900.3 for the area of range safety (Requirement).
- e. Participate in panels, joint working groups, and other range safety policy initiation and change activities that affect NASA operations and/or use of ranges (Requirement).
- f. Coordinate activities and actions with NASA Center range safety personnel and other entities, including the FAA and DoD, to formulate, recommend, and evaluate policies, procedures, and standards and to ensure that NASA programs and Centers use range safety practices that are consistent with applicable laws, national standards, and NASA requirements (Requirement).
- g. Provide NASA programs with sources of range safety expertise to support independent process reviews, flight readiness reviews, and other safety reviews (Requirement).
- h. Provide input and recommendations to NASA Headquarters Office of Safety and Mission Assurance (OSMA) and other authorities (including designated SMA Technical Authorities) during review and approval processes when range safety requirements are a consideration (Requirement).
- Note: SMA Technical Authority and associated responsibilities are defined in NPR 7120.5, NASA Space Flight Program and Project Management Requirements.*
- i. Establish and maintain a range safety training program (Requirement).
- j. Facilitate the development of tools for assessing range safety risks (Requirement).
- k. For each NASA range operation that is not supported by a Center range safety organization, evaluate tailoring, requests for Equivalent Level of Safety (ELS) determinations, and Range Safety Waivers and coordinate with the approval authorities per paragraph 1.4, 1.5, and 1.6 of this NPR (Requirement).
- l. For each vehicle program that is not supported by a Center range safety organization, evaluate the program's range safety risk management process per paragraph 3.2.4 of this NPR and coordinate with the approval authorities (Requirement).
- m. Generate NASA range safety annual reports for OSMA (Requirement).
- n. Ensure NASA range flight safety functions are performed for all NASA range operations. For each vehicle program that is not supported by a Center range safety organization, this includes, but is not limited to, monitoring of vehicle operations and range processes to ensure timely identification and resolution of any violation that might affect operational approval (Requirement).
- o. Coordinate with OSMA in annual planning of Agency Range Flight Safety Program activities and



budget (Requirement).

### 1.3.3 Center Directors.

1.3.3.1 Each Center Director (or NASA designee) shall:

- a. Ensure the implementation of this NPR for each Center program that involves range operations (Requirement).
- b. Designate a Center Range Safety Representative (see paragraph 1.3.5) (Requirement).
- c. Ensure coordination with all organizations that support a program's range operations (Requirement).

*Note: For additional Center Director responsibilities regarding Range Safety Waivers, see paragraph 1.6.5.*

1.3.3.2. When functioning as the authority for a range, launch site (fixed or mobile), or landing site (including any airfield used for range operations) or when onsite personnel are affected by range operations, the Center Director or NASA designee shall:

- a. Establish the processes and associated Center-level requirements needed to ensure the requirements of this NPR are satisfied, including the risk management process of paragraph 3.2.4 of this NPR (Requirement).
- b. Ensure all employees and visitors are informed of potential hazards associated with a range operation and the actions to take in the event of an emergency (Requirement).
- c. Support and ensure that the Certificate of Flight Readiness or equivalent review process includes range safety considerations (Requirement).
- d. Support development of emergency response plans and ensure coordination with appropriate emergency response agencies to prevent or mitigate the exposure of the public or workforce to any hazard associated with a range operation (Requirement).

*Note: NPD 8710.1, NASA Emergency Preparedness Program, and NPR 8715.2, NASA Emergency Preparedness Plan Procedural Requirements, apply with regard to emergency preparedness.*

- e. Approve the categorization of people located on NASA property as Mission Essential Personnel, Critical Operations Personnel, or public/visitors for the purposes of risk management (Requirement).
- f. Approve each vehicle program's range safety risk management process per paragraph 3.2.4 of this NPR (Requirement).

1.3.3.3 When functioning as the safety authority for range operations, the Center Director or NASA designee shall designate a Center range safety organization that satisfies paragraph 1.3.4 of this NPR (Requirement).

1.3.4 Center Range Safety Organization. The Center range safety organization lead or NASA designee shall:

- a. Report to the Center Director or NASA designee on all range safety concerns and ensure the implementation of this NPR and associated Center-level processes and requirements (Requirement).
- b. Identify program data requirements and perform or evaluate and approve required range safety analysis (Requirement).

- c. Evaluate and approve all range safety systems (Requirement).
- d. Ensure that personnel performing range safety functions have the qualifications and training that satisfy paragraph 3.8 of this NPR (including Range Safety Officers (RSOs) and personnel responsible for range safety systems and range safety analysis) appropriate to the types of vehicles and range operations (Requirement).
- e. Ensure the operational performance requirements and standards for all range safety systems satisfy paragraph 3.3 of this NPR (Requirement).
- f. Ensure the readiness of the range safety systems to support each operation (example: conduct and/or participate in pre-operation functional tests and system checks on the day of the operation) (Requirement).
- g. Coordinate with maritime, aviation, and other authorities to ensure all range safety requirements are satisfied for all range operations (Requirement).
- h. Evaluate tailoring and requests for ELS determinations and Range Safety Waivers and coordinate these with the approval authorities per paragraphs 1.4, 1.5, and 1.6 of this NPR (Requirement).
- i. Evaluate each vehicle program's range safety risk management process per paragraph 3.2.4 of this NPR and coordinate this with the approval authorities (Requirement).
- j. Provide operational support for range operations. This includes monitoring vehicle operations and range processes to ensure timely identification and resolution of any violation of range safety requirements (Requirement).
- k. Designate a qualified RSO or equivalent for each NASA mission that involves range operations (see paragraph 1.3.7 of this NPR for RSO responsibilities) (Requirement).

### 1.3.5 Range Safety Representative.

1.3.5.1 A Range Safety Representative may represent a Center, vehicle program, or both.

1.3.5.2 Each Range Safety Representative shall:

- a. Monitor the Center and/or vehicle program implementation of this NPR (Requirement).
- b. Keep the NASA Range Safety Manager advised of activities related to range safety (Requirement).
- c. Provide the NASA Range Safety Manager with an annual summary of all range safety activities associated with each program where applicable (Requirement).
- d. Lead and/or participate in range safety activities as designated by the Center Director or vehicle program manager (Requirement).
- e. Coordinate tailoring per paragraph 1.4 and any requests for ELS determinations and Range Safety Waivers per paragraphs 1.5 and 1.6 of this NPR.
- f. Brief the Center Director, vehicle program manager, and/or other cognizant managers on pertinent range safety requirements contained in this NPR and on proper implementation (Requirement).

1.3.6 NASA Vehicle Program Manager. For each range operation, the NASA vehicle program manager or NASA designee shall:

- a. Ensure the requirements of this NPR and the requirements of each range, launch site, or landing site that support the range operation are satisfied, including the risk management process of paragraph 3.2.4 of this NPR (Requirement).

- b. Coordinate all risk management efforts with all cognizant range safety organizations and the authority for any range, launch site, or landing site that support the range operation (Requirement).
- c. Coordinate with all cognizant range safety organizations and Center/Program Range Safety Representative(s) to develop and implement operational range safety requirements, plans, procedures, and checklists, including mission rules and launch/flight commit criteria (see paragraph 3.4 of this NPR for operational requirements) (Requirement).
- d. Designate a Range Safety Representative for the vehicle program (see paragraph 1.3.5) (Requirement).
- e. Involve range safety personnel throughout all pertinent vehicle and payload reviews and during operations (Requirement).
- f. Begin the range safety requirements tailoring process prior to the Systems Requirement Review (SRR) or equivalent initial review (Requirement).
- g. Ensure adequate resources and data are provided to implement range safety requirements. (Requirement). This includes, but is not limited to:
  - (1) The design, test, and implementation of vehicle range safety systems (Requirement).
  - (2) The participation of all cognizant range safety organizations and authorities in the range safety review and approval process (Requirement).
  - (3) Operational support provided by all cognizant range safety organizations (Requirement).
- h. Incorporate the requirements of this NPR in all contracts and agreements (Requirement).
- i. Process tailoring, ELS determinations, and Range Safety Waivers in accordance with paragraphs 1.4, 1.5, and 1.6 of this NPR (Requirement).
- j. Coordinate with all cognizant range safety organizations to generate a contingency action plan that satisfies NPR 8621.1, NASA Procedural Requirements for Mishap and Close Call Reporting, Investigating, and Recordkeeping (Requirement).
- k. Coordinate with all cognizant range safety organizations and the emergency planning community to generate emergency response planning actions (including, but not limited to, Center or local safety office, emergency responders, local jurisdictions, and the cognizant NASA environmental management organization) (Requirement).

*Note: NPD 8710.1, NASA Emergency Preparedness Program, and NPR 8715.2, NASA Emergency Preparedness Plan Procedural Requirements, apply with regard to emergency preparedness.*

- l. In coordination with the cognizant Center/range organization(s), ensure all employees and visitors are informed of potential hazards associated with a range operation and the actions to take in the event of an emergency (Requirement).
- m. Ensure that employees whose duties involve the potential for exposure to hazardous materials are educated, at a minimum, in accordance with 29 CFR 1910.1200, Hazard Communication (Requirement). This includes awareness of propellant and explosive products and hazards and vapors, particulate matter, and airborne plumes applicable to range operations.
- n. Provide all cognizant range safety organizations with all data pertinent to the range safety review and approval process (Requirement).

- o. Engage the cognizant Center range safety organization or the NASA Range Safety Manager to establish a plan for monitoring of vehicle operations and range processes to ensure timely identification and resolution of any violation that might affect operational approval (Requirement).
  - p. Develop, document, and approve a range safety risk management process for the vehicle program that satisfies paragraph 3.2.4 of this NPR (Requirement).
- (1) Review the process to ensure its validity for each range operation and update as needed (Requirement).
  - (2) Coordinate the process documentation and any updates with the cognizant Center range safety organization or NASA Range Safety Manager and the Center/Program Range Safety Representative(s) prior to submittal for final approval (Requirement).
  - (3) If the vehicle operates at a NASA range, launch site, or landing site, obtain approval of the process (including any updates) by each cognizant NASA Center Director or NASA designee (Requirement).
  - (4) Obtain approval of the process documentation (including any updates) by the cognizant SMA Technical Authority(ies) (Requirement).
- q. Ensure that any vehicle program personnel who perform a range safety function are qualified and trained in accordance with paragraph 3.8 of this NPR (Requirement).

*Note: See paragraphs 1.4, 1.5, and 1.6 of this NPR for additional Vehicle Program Manager responsibilities regarding tailoring, ELS determination, and Range Safety Waiver processes.*

### 1.3.7 Range Safety Officer (RSO) (or equivalent).

1.3.7.1 The RSO or equivalent for each NASA range operation shall be a qualified NASA or DoD employee or a person operating under an FAA license (see paragraph 3.8 of this NPR for applicable personnel qualification requirements) (Requirement).

1.3.7.2 The RSO or equivalent for each NASA range operation shall:

- a. Undergo simulation scenarios that exercise hands-on operations of range safety systems, safety decision-making tools, and processes (including contingency actions) in conjunction with vehicle systems (Requirement).
- b. Coordinate with the program to develop and implement operational range safety requirements, plans, procedures (including contingency plans and procedures), and checklists, including mission rules and launch/flight commit criteria (see paragraph 3.7 of this NPR for operational requirements) (Requirement).

*Note: The contingency plans and procedures include actions to be taken if the RSO is suddenly unable to perform related real time duties (e.g., due to sudden illness).*

- c. Coordinate with the program and responsible approval authorities on tailoring, ELS determinations, and any Range Safety Waivers (Requirement).
- d. Ensure that all range safety commit criteria are satisfied prior to initiating each phase of flight (see paragraph 3.2.4.3e. of this NPR regarding phases of flight) (Requirement).

1.3.7.3 For any vehicle that has a Flight Termination System (FTS), the RSO or equivalent shall:

- a. Coordinate with the program to develop flight termination activation criteria (Requirement).

- b. Perform real-time monitoring of the vehicle flight path/trajectory, vehicle systems, range safety systems, and the performance of the FTS (Requirement).
- c. Make a flight termination decision when any aspect of the flight (including, but not limited to, vehicle or support system performance) violates preplanned termination criteria (Requirement).

## 1.4 Range Safety Tailoring Process

1.4.1 The overall intent of the range safety requirements tailoring process is to ensure proper interpretation and implementation of range safety requirements while providing the Centers and program managers with the authority and flexibility needed to accomplish their tasks. For the purposes of the NASA Range Safety Program and this NPR, tailoring is defined as the process where the range user and the authorities responsible for the range safety requirements review each requirement and jointly document whether the requirement is applicable to the range user's operations and, if it is applicable, document whether the range user will meet the requirement as written or achieve an equivalent level of safety through an acceptable alternative.

*Note: NASA actively participates with the national range safety community in order to effectively conduct NASA range operations. It is necessary for the NASA Range Safety Tailoring Process to be consistent with the approach used at the national ranges. Range safety tailoring may include ELS determinations (see paragraph 1.5 of this NPR). Range safety tailoring does not include the approval of Range Safety Waivers, which is handled in a separate process (i.e., tailoring does not incorporate the acceptance of increased safety risk). See paragraph 1.6 of this NPR.*

1.4.2 Each vehicle program designated range safety representative and other applicable vehicle program personnel shall:

- a. Work with the cognizant Center range safety organization, Center Range Safety Representative, or the NASA Range Safety Manager and all other involved range safety authorities (such as the Air Force) to identify and assess compliance with this NPR and other applicable range safety requirements (Requirement).
- b. Tailor a set of program- or mission-specific range safety requirements (working directly with the cognizant Center range safety organization or NASA Range Safety Manager) and compile those requirements into a program- or mission-specific document (Requirement).

*Note: Lessons Learned - Programs should not attempt to self-tailor or interpret range safety requirements without direct assistance from the cognizant Center range safety organization or the NASA Range Safety Manager. Attempting to self tailor range safety requirements may result in misinterpretation of the applicability of requirements and may lead to unnecessary schedule and cost impacts associate with late corrections.*

- c. Ensure that the document containing the tailored range safety requirements identifies any change to a requirement (including any addition or deletion) and includes sufficient rationale for the tailored change (Requirement).

1.4.3 The Center range safety organizations, the Range Safety Representatives, and the NASA Range Safety Manager shall coordinate as needed to allow for consistent application of range safety tailoring throughout the Agency (Requirement).

1.4.4 The signatories of each tailored requirements document shall include, but are not limited to the vehicle program manager (or designee) and the cognizant SMA Technical Authority(ies) after obtaining documented concurrence from the cognizant Center range safety organization or the NASA Range Safety Manager and any other authorities responsible for issues addressed by the



tailoring.

*Note: The vehicle program should coordinate with the cognizant Center range safety organization or NASA Range Safety Manager when establishing the mission timeline/schedule to ensure that it incorporates sufficient time to complete the tailoring process and to implement the tailored requirements.*

1.4.5 After approval, any further proposed change to the tailored requirements document shall be documented and distributed by the vehicle program as a change page or equivalent document for coordination and approval/concurrence by the original signing authorities (Requirement).

*Note: For an ELS determination after approval of the tailored requirements document see paragraph 1.5.3 of this NPR.*

1.4.6 If the Center range safety organization, NASA Range Safety Manager, or other range safety authority determines that proposed tailoring of a requirement (i.e., deletion of a requirement, a change to a requirement, or an approach that differs from the stated requirement) results in increased safety risk, the vehicle program shall prepare a waiver request and obtain approval per paragraph 1.6 of this NPR (Requirement).

1.4.7 In the event that an authority does not concur on a tailored requirements document and the issue cannot be resolved through coordination with the cognizant/designated SMA Technical Authority, all interested parties shall brief their position to the next higher level SMA Technical Authority and so on until resolved (Requirement).

## 1.5 Equivalent Level of Safety (ELS)

1.5.1 An ELS determination is a noncompliance with a range safety requirement where the cognizant range safety organization approves an alternate approach that provides an approximately equal level of safety as determined by qualitative or quantitative means. An ELS applies when the alternate approach satisfies both of the following conditions:

- a. There is a high degree of certainty that the alternate approach will not increase the probability that Range Safety System hardware will fail, considering all required design environments; AND
- b. The alternate approach will not add any single failure point(s) in Range Safety System hardware onboard the vehicle.

*Note: The primary purpose of required redundancy in onboard range safety systems is to provide survivability (i.e., not necessarily reliability). Single failure points in onboard range safety system hardware directly affect the ability of the safety system to survive and function during a breakup failure scenario. Detailed range safety system requirements identify acceptable single failure points in onboard safety systems. In general, any additional single failure point will result in increased safety risk and is processed as a Range Safety Waiver per paragraph 1.6 of this NPR.*

1.5.2 Each program shall ensure that ELS determinations made during the initial tailoring process are clearly identified in the tailored requirements document and that the document contains or references sufficient approval rationale for each ELS determination (Requirement).

1.5.3 For any ELS requested after approval of the tailored requirements document but prior to commencement of the range operation:

1. The requesting program shall prepare a written ELS request that provides approval rationale



(Requirement).

*Note: The NASA Range Safety Manager maintains the latest NASA Range Safety ELS request format and makes it available to all programs. Similar formats used at the various ranges are also acceptable.*

2. The cognizant SMA Technical Authority(ies) and the vehicle program manager (or designee) shall approve (sign) the ELS after obtaining documented concurrence from the cognizant Center range safety organization or the NASA Range Safety Manager and any other authorities responsible for issues addressed by the ELS (Requirement).

1.5.4 If an ELS is approved in real time during a range operation, the requesting program, cognizant SMA Technical Authority(ies), and cognizant Center range safety organization or NASA Range Safety Manager shall ensure that a record of the ELS request, rationale, and approval is generated and maintained as part of the official operation records (Requirement).

*Note: This may be accomplished in real time through the use of a recorded voice network and then documented, in writing, after the operation is complete.*

1.5.5 Each Center range safety organization, the Center/Program Range Safety Representatives, the NASA Range Safety Manager, and the SMA Technical Authorities shall coordinate as needed to allow for consistent ELS determinations throughout the Agency (Requirement).

## 1.6 Range Safety Waiver Process

1.6.1 The following is a specific implementation of NASA policy for processing and approving waivers as they apply to range safety requirements. For the purpose of the NASA Range Flight Safety Program and this NPR, a Range Safety Waiver is defined as a written authorization allowing a range operation to continue even though a specific range safety requirement is not satisfied and the vehicle program is not able to demonstrate an equivalent level of safety. A Range Safety Waiver typically applies to a single mission but may have other limited applicability.

*Note: NASA actively participates with the national range safety community in order to effectively conduct NASA range operations. It is necessary for the NASA Range Safety Waiver process to be consistent with the approach used at the national ranges. The range safety community only documents waivers in cases that involve the acceptance of increased risk (i.e., "Range Safety Waivers" always involve the acceptance of increased safety risk). The only other form of approved noncompliance with a range safety requirement is an ELS (see paragraph 1.5 of this NPR).*

1.6.2 The requesting program shall coordinate each Range Safety Waiver request with the Center range safety organization or the NASA Range Safety Manager, the Center/Program Range Safety Representative(s), and any other cognizant range safety organization(s) to:

- a. Ensure that the Range Safety Waiver request and accompanying data are correct and complete (including identification of appropriate risk mitigations) (Requirement).
- b. Ensure that the risk is properly identified and characterized (Requirement).
- c. Assess any effects the Range Safety Waiver might have on other projects, resources, or requirements (Requirement).
- d. Ensure approval, concurrence, and risk acceptance by appropriate authorities (Requirement).

1.6.3 Prior to the affected range operation, the requesting program shall draft a written Range Safety Waiver request (Requirement). For real-time Range Safety Waivers, see paragraph 1.6.6 of this NPR.

*Note: The NASA Range Safety Manager maintains the latest NASA Range Safety Waiver request format and makes it available to all programs (see [http://kscsma.ksc.nasa.gov/Range\\_Safety/](http://kscsma.ksc.nasa.gov/Range_Safety/)). Similar formats used at the various ranges are also acceptable.*

1.6.4 Center/program Range Safety Representatives shall coordinate with all cognizant range safety organizations as soon as a potential noncompliance with a range safety requirement is identified (Requirement).

1.6.5 The Range Safety Waiver approval process shall incorporate the following:

- a. The cognizant Center range safety organization or the NASA Range Safety Manager shall evaluate all Range Safety Waiver requests and provide input to the SMA Technical Authority(ies) and other approval authorities (Requirement).
- b. The cognizant SMA Technical Authority(ies) shall sign each Range Safety Waiver indicating the risk is properly characterized and recommending acceptance (Requirement).
- c. For any vehicle flown under the cognizance of a NASA range, the NASA Center Director (or NASA designee) responsible for the NASA range shall sign each Range Safety Waiver indicating consent to accept the associated risk to people or property (including public) (Requirement).
- d. For a NASA range operation that does not involve a NASA or other United States Government range (e.g., an entry operation), the NASA Center Director (or NASA designee) that hosts the vehicle program shall sign each Range Safety Waiver indicating consent to accept the associated risk to people or property (including public) (Requirement).
- e. The vehicle program manager (or designee) shall sign each Range Safety Waiver indicating acceptance of all safety risk associated with the waiver (Requirement).

*Note: For non-NASA vehicles at a NASA range, the SMA Technical Authority(ies) and the Center Director/designee signatures (per paragraphs 1.6.5.b and 1.6.5.c of this NPR) constitute NASA approval of the waiver. The required NASA signatures are in addition to any local approvals required when utilizing a non-NASA range, such as approval by the Air Force Range Commander for launches utilizing an Air Force range. Such local approvals may be documented on the same waiver document as the NASA signatures or on a separate equivalent document depending on local agreements and procedures.*

1.6.6 If a Range Safety Waiver is approved in real time during a range operation, the requesting program and all cognizant range safety organizations shall coordinate to ensure that the requirements of paragraph 1.6.4 and 1.6.5 of this NPR are satisfied and that a record of the waiver request, rationale, and approval is generated and maintained as part of the official operation records (Requirement).

*Note: This may be accomplished in real time through the use of a recorded voice network and then documented, in writing, after the operation is complete.*

1.6.7 The Center range safety organizations, Center/program Range Safety Representatives, SMA Technical Authorities, and NASA Range Safety Manager shall coordinate as needed to allow for a consistent Range Safety Waiver approach throughout the Agency (Requirement).

1.6.8 In the event that a required signatory does not concur on a Range Safety Waiver and the issue cannot be resolved through coordination with the cognizant/designated SMA Technical Authority and the other required approval authorities, all interested parties shall brief their position to the next higher level authorities and so on until resolved (Requirement).

# Chapter 2. Unique Range Safety Policies and Requirements

## 2.1 Introduction

Unique range safety policies and requirements may apply to range operations depending on the location of the operation or the participation of other entities. This chapter identifies unique range safety policies and requirements for range operations that involve commercial launch and entry service providers, the National Airspace System, and participation by foreign entities.

## 2.2 Commercial Launch and Entry

2.2.1 The FAA has the authority to authorize and supervise commercial space transportation activities conducted in the United States (by U.S. and non-U.S. citizens) or by a U.S. citizen (conducting activities inside or outside the United States). Specifically, the FAA licenses commercial launch and entry operations and the operation of commercial launch sites. A NASA program may involve any combination of licensed or unlicensed space transportation activities. For example, a licensed commercial launch may take place from a licensed site operator, or from a NASA or DoD range which does not require a site operator license. Conversely, a Government launch that is not licensed by the FAA may take place from a site operated under an FAA license. The FAA licensing regulations are contained in 14 CFR Parts 400-1199, Commercial Space Transportation.

2.2.2 A NASA launch or entry does not require an FAA license if the activity is conducted by or for NASA and NASA is so substantially involved that it effectively directs or controls the activity. For a NASA (non-FAA licensed) launch or entry, the NASA program shall:

- a. Supervise the activities of each contractor providing a launch or entry service by approval of requirements and ongoing involvement with the contractor (Requirement).
- b. Ensure that a Government organization directly oversees and performs the range safety function during the activity (Requirement).

2.2.3 A NASA program may require FAA licensing for commercial ventures funded by NASA or a commercial launch or entry carrying a NASA payload (as a primary customer).

*Note: NASA programs should weigh the benefits of FAA licensing vs. the benefits of conducting operations under NASA range/public safety authority as applicable to each program's specific mission needs.*

2.2.4 A NASA program shall require FAA licensing for any launch or entry where there is no Government organization directly overseeing and performing the range safety function during the activity (Requirement).

*Note: FAA licensed launches and entries are subject to FAA procedural and technical requirements contained in 14 CFR "Parts 400-1199" Commercial Space Transportation. An FAA-licensed launch or entry carrying a NASA payload or otherwise supporting a NASA mission does not constitute a NASA range operation and is not subject to the requirements contained in this NPR unless the activity takes place at a NASA facility where the cognizant/local NASA range safety organization is required to implement aspects of this NPR that apply to the*

*activity. In such cases NASA will coordinate with the FAA to ensure all applicable range safety requirements are satisfied.*

## **2.3 National Airspace System**

This paragraph applies to each NASA program that uses the National Airspace System during conduct of a range operation.

2.3.1 A NASA program shall coordinate with the FAA on each range operation that uses the National Airspace System (Requirement).

2.3.2 A NASA program shall obtain a Certificate of Authorization or Waiver (COA) from the FAA for each UAS operation within the National Airspace System outside of authorized Special Use Airspace (Requirement).

2.3.3 A NASA program shall coordinate the required information with range safety personnel prior to submitting the request to the FAA center(s) with authority over the planned areas of operation (Requirement).

## **2.4 Foreign Participation in NASA Range Operations**

A foreign entity may participate in a NASA range operation within the United States or at a foreign location. A NASA range operation may involve the use of a foreign range or airspace, for example, as an alternate landing site, primary landing site, contingency landing site, or the site of a launch or environmental research mission.

2.4.1 Foreign participation in any NASA range operation shall require prior coordination with the NASA Office of International and Interagency Relations and be conducted in accordance with this NPR; NPD 1360.2, Initiation and Development of International Cooperation in Space and Aeronautics Programs; and NPD 1050.1, Authority To Enter Into Space Act Agreements (Requirement).

2.4.2 Foreign participation in any NASA range operation which requires access to NASA Installations or Facilities shall also be conducted in accordance with paragraph 2.4.1 of this NPR; NPR 1371.2, Procedural Requirements for Processing Requests for Access to NASA Installations or Facilities by Foreign Nationals or U.S. Citizens Who are Representatives of Foreign Entities; and/or NPD 1371.5, Coordination and Authorization of Access by Foreign Nationals and Foreign Representatives to NASA (Requirement).

2.4.3 Placing a NASA payload and/or NASA astronaut on a foreign vehicle that is operated under a foreign government range/public safety authority does not constitute a NASA range operation. Such activities are not subject to this NPR unless specified by the applicable contract or agreement. This NPR does apply if such an activity is not performed under a foreign government range safety authority.

# Chapter 3. Range Flight Safety

## 3.1 Introduction

Range flight safety considerations include three elements: range safety analysis, range safety systems, and operational requirements. This chapter provides a basic description of these elements and related concepts and provides the associated requirements. This chapter also provides requirements that apply to the qualification and training of personnel who perform range safety functions.

## 3.2 Range Safety Analysis

3.2.1 A vehicle program, in coordination with a Center range safety organization or the NASA Range Safety Manager, shall ensure that each range operation undergoes a range safety risk analysis to establish any design or operational constraints needed to control risk to persons or property (Requirement).

3.2.2 A Center range safety organization or the NASA Range Safety Manager shall review and approve the range safety risk analysis (Requirement).

3.2.3 A range safety risk analysis shall incorporate the elements of risk management; i.e., risk assessment, risk mitigation, containment, and risk acceptance (Requirement).

*Note: Containment for the purposes of range safety is defined in Appendix A, and related requirements are in paragraph 3.2.9 of this NPR.*

### 3.2.4 Range Safety Risk Management Process.

*Note: The range safety risk management process is a specific implementation of the general risk management approach defined in NPR 8000.4, Agency Risk Management Procedural Requirements.*

3.2.4.1 A Center's or vehicle program's range safety risk management process shall include assessment of the risk to the public, workforce, and property in accordance with paragraph 3.2.5 of this NPR (Requirement).

3.2.4.2 A vehicle program's range safety risk management process shall incorporate the applicable requirements of any range, launch site, or landing site that supports the program's range operations (Requirement).

3.2.4.3 Within the range safety risk management process, the vehicle program, all cognizant range safety organizations, and the authority responsible for the range, launch site, or landing site shall coordinate with each other and with any other range users/tenants and public or private entities in the flight vicinity to:

- a. Mitigate the risk to members of the public and the workforce (Requirement).
- b. Identify any property in the vicinity of the flight that requires protection from potential debris impact and/or other hazards, identify the potential damage of concern, and mitigate the associated risk (Requirement).

*Note: Local authorities and programs are responsible for determining what property requires*



*protection. Local authorities may have risk management requirements that apply to certain high-value equipment, assets, or other property. There may be specific property for which the program requires risk management due to its proximity to the flight and the consequences associated with potential hazards.*

- c. Perform and document the risk assessment per paragraph 3.2.5 of this NPR (Requirement).
- d. Make risk acceptance/disposition decisions that integrate concerns for public risk, workforce risk, risk to any property identified under paragraph 3.2.4.3.b, mission risk, including the risk to the safety of any flight crew, and mission constraints (Requirement).
- e. Make operational decisions needed to control risk prior to initiation of flight or each phase of flight (Requirement):
  - (1) For an orbital RLV or vehicle that operates continuously for extended periods, the responsible organization(s) may make operational decisions, including the implementation of applicable per flight risk criteria, independently for each phase of flight (e.g., launch, entry, ascent, cruise, or descent) if all three of the following are satisfied:
    - (a) Each decision is based on a risk assessment that is conducted or revalidated just prior to each phase of flight.
    - (b) The assessment or revalidation accounts for updated vehicle status and updated predictions of flight conditions.
    - (c) The vehicle has sufficient controllability to allow for risk management as a prerequisite to beginning each phase of flight.
  - (2) For a mission that involves the operation of more than one vehicle simultaneously, the responsible organization(s) may make operational decisions, including the use of applicable per flight risk criteria, independently for each vehicle if each vehicle has sufficient independent controllability to allow the management of risk individually for the flight of each vehicle.
- f. Document decisions concerning approval of operations, acceptance/disposition of safety risk including justification, and the application of any additional safety controls or constraints based on safety evaluations (Requirement).
- g. Inform all employees and visitors on NASA-controlled property of potential hazards associated with range operations and the actions to take in the event of an emergency (Requirement).
- h. Manage any risk associated with planned and unplanned debris and/or potentially hazardous material that remains after impact (e.g., potential hazards to navigation due to floating debris, potential public exposure to explosive debris or toxic material, etc.) (Requirement).

3.2.4.4 The vehicle program shall develop and maintain formal documentation that provides the details of the vehicle program's range safety risk management process (Requirement).

*Note: This documentation may take the form of a standalone plan or consist of a compilation of program documents such as tailored range safety requirements, ELS determinations, Range Safety Waivers, risk mitigation procedures, and launch/flight commit criteria. This documentation includes the risk management requirements and processes of any other organization that supports the program, such as the range, launch site, or landing site.*

3.2.4.5 Risk Criteria. Each range operation shall satisfy the following criteria for assessed risk unless higher risk levels are specifically authorized for the operation (Requirement).

*Note: The risk criteria within paragraph 3.2.4.5 of this NPR are consistent with RCC 321, Range Commanders Council Common Risk Criteria for National Test Ranges. RCC 321 and the RCC 321 Supplement contain background and justification for the risk criteria.*

*In general, these criteria define a level of assessed risk to the public, workforce, and property that the Agency accepts for all range operations without higher management review. If a range operation is to exceed any of these criteria, the Range Safety Waiver Process and associated requirements outlined in section 1.6 of this NPR apply.*

*Unless otherwise stated for a specific criterion, these criteria apply to the aggregate risk resulting from the combination of all hazards associated with a range operation.*

*In general, the risk criteria within paragraph 3.2.4.5 of this NPR apply per flight. They may be applied per phase of flight in accordance with paragraph 3.2.4.3.e of this NPR.*

a. Individual Risk.

(1) Probability of casualty ( $P_C$ )  $\leq 1 \times 10^{-6}$  for individual people who are not mission essential or critical operations personnel (Requirement).

(2)  $P_C \leq 1 \times 10^{-6}$  for mission essential or critical operations personnel (Requirement).

*Note: For purposes of consistency with DoD and FAA range safety policy, the specific hazards considered in a range safety risk assessment are defined in paragraph 3.2.5.7 of this NPR.*

b. Property Impact Probability. Probability of debris impact  $\leq 1 \times 10^{-3}$  for any property identified under paragraph 3.2.4.3.b that could result in the damage of concern identified under paragraph 3.2.4.3.b, applied for each flight (Requirement).

c. Collective Risk.

(1) Collective Risk Criterion for the combination of Mission Essential Personnel and Critical Operations Personnel: Expectation of Casualty ( $E_C$ )  $\leq 300 \times 10^{-6}$  (Requirement).

(2) Collective Public Risk Criteria:  $E_C \leq 100 \times 10^{-6}$  (Requirement).

*Note: Public includes all people who are not Critical Operations Personnel or Mission Essential Personnel and are on land, on waterborne vessels, and in aircraft. Range safety implementation of the EC criteria often includes the use of impact probability criteria, which ensure that any people on waterborne vessels or in aircraft do not contribute significantly to the overall public collective risk.*

*Space Shuttle: NASA has approved special collective public risk management provisions for the Space Shuttle that are in effect through the end of the Space Shuttle Program. Due to the established design and operational constraints, any significant alterations to Space Shuttle launch and entry operations would have the potential for negative effects on crew and mission. The special provisions allow the Space Shuttle Program to continue to use KSC as its primary launch and landing site, with Edwards Air Force Base and White Sands Missile Range as backup landing sites. The Space Shuttle Program, in coordination with NASA Headquarters, has quantified and thoroughly evaluated the risks associated Space Shuttle launches and landings. The public risk criteria, risk assessments, and risk management process for Space Shuttle are detailed in Space Shuttle Program and KSC documents which are available from the NASA Range Safety Manager upon request.*

### 3.2.5 Range Safety Risk Assessment.

3.2.5.1 A range safety risk assessment shall be a formal documented analysis that identifies and characterizes risk for input to the risk management process (Requirement).

3.2.5.2 The risk assessment shall employ quantitative means unless all cognizant range safety organizations and other authorities agree that quantitative assessment is not necessary or not feasible; in which case the risk assessment shall employ qualitative measures (Requirement).

3.2.5.3 The risk assessment shall provide a best estimate of the risks and include an evaluation of uncertainty bounds or sensitivities to inputs (Requirement).

3.2.5.4 The assessment documentation shall identify all assumptions made (Requirement).

3.2.5.5 The risk assessment shall account for variability associated with the following:

- a. Each source of hazard, including any associated with a payload, during flight (Requirement).
- b. Normal flight and each appropriate foreseeable failure response mode of the vehicle for each flight phase (Requirement).
- c. Each appropriate foreseeable external and internal vehicle flight environment (Requirement).
- d. Public and worker population potentially exposed to the flight (Requirement).
- e. Population growth rates in order to remain valid if a risk assessment will apply to a number of flights over a number of years (Requirement).
- f. The performance of any range safety system, control, or constraint including all associated time delays (Requirement).

3.2.5.6 Input data used for the range safety risk assessment shall include:

- a. Vehicle reliability unless the vehicle will operate under full containment per paragraph 3.2.9 of this NPR (Requirement).
- b. Proposed trajectories (nominal, preplanned contingency, abort, and malfunction trajectories) (Requirement).
- c. Description of any landing sites and/or flight paths (Requirement).
- d. Description of credible failure modes and their probability of occurrence resulting in a hazard to public safety (Requirement).
- e. Reliability of any range safety system (Requirement).
- f. All hazard controls and mitigation strategies (Requirement).
- g. Pertinent vehicle information, such as size, weight, propellant types and amounts, and any explosives, pressurized vessels potential for high energy release, toxic materials, or radionuclides (Requirement).
- h. Other relevant data required for analysis in support of specific mission objectives, including related payload information and data from pertinent lessons-learned reports (Requirement).

3.2.5.7 There are typically three types of hazards considered in a range safety risk assessment. These include debris, distant focusing overpressure, and toxic material release (see paragraphs 3.2.6, 3.2.7, and 3.2.8 respectively of this NPR).

- a. A risk assessment shall account for the risk due to each hazard where applicable for each flight

unless the hazard is fully contained (Requirement).

*Note: Containment for the purposes of range safety is defined in Appendix A, and related requirements are in paragraph 3.2.9 of this NPR.*

b. Other hazards may exist based on specific mission requirements, and these hazards shall be included in the assessment on a case-by-case basis (Requirement).

### 3.2.6 Debris Risk Assessment.

3.2.6.1 A range safety analysis shall assess any risk due to debris for input to the risk management process (Requirement). For a launch, these requirements apply to any debris that does not achieve orbital insertion. For an entry operation, these requirements apply to any debris that might be generated, intentionally or not, after the deorbit burn or sample return capsule release. Any orbital debris is subject to the requirements of NPR 8715.6, NASA Procedural Requirements for Limiting Orbital Debris.

3.2.6.2 An assessment of risk to the public and workforce due to debris shall account for each of the following as a function of flight-time or loss-of-control-time:

a. All potential debris, generated intentionally or not, that could cause a casualty, including debris that could affect someone on the ground or on a waterborne vessel, or cause an aircraft accident (Requirement).

*Note: Casualty models used in range safety risk assessments typically evaluate certain impact parameters, such as kinetic energy, and incorporate thresholds on those parameters that define when a debris impact has the potential to cause a casualty or down an aircraft. These thresholds may change as our knowledge of human vulnerability/aircraft vulnerability evolves. Sources of the latest casualty and aircraft impact thresholds developed for use by the range safety community include RCC 321, Common Risk Criteria Standard for National Test Ranges: Inert Debris, and AFSPCMAN 91-710, Range Safety User Requirements Manual.*

b. All populated areas in the overflight area that could be impacted by the debris (Requirement).

c. The probability of the debris impacting each populated area, which accounts for the probability of vehicle failure (Requirement).

d. The effective casualty area of the impacting debris, which accounts for the cross-sectional area of the debris, average size of a person, and the effects of any overpressure due to any explosive debris (debris that would explode on or after impact) (Requirement).

e. The population density of each populated area (Requirement).

*Note: The assessment should consider any risk mitigation factors associated with each population, such as sheltering and time of day of the flight.*

f. Debris variability, including size, shape, aerodynamic properties, weight, and potential to survive to impact (Requirement).

g. The sources of debris variability, including breakup conditions (Requirement).

h. The uncertainties in the state vector at the instant of jettison or destruct and any correlations used (Requirement).

i. Any velocity imparted to the debris fragments during jettison, destruct, or breakup (Requirement).

j. The influence of atmospheric variability, including winds (Requirement).

3.2.6.3 A debris risk assessment for any property identified under paragraph 3.2.4.3.b shall account for:

- a. All potential debris (intentionally or unintentionally generated) that could cause property damage, which accounts for the specific nature of the property (Requirement).
- b. The cross-sectional area of the debris and the effects of any overpressure due to any explosive debris (debris that would explode on or after impact) (Requirement).
- c. Debris variability, including size, shape, aerodynamic properties, weight, and potential to survive to impact (Requirement).
- d. The sources of debris variability, including breakup conditions (Requirement).
- e. The uncertainties in the state vector at the instant of jettison or destruct and any correlations used (Requirement).
- f. Any velocity imparted to the debris fragments during jettison, destruct, or breakup (Requirement).
- g. The influence of atmospheric variability, including winds (Requirement).
- h. The probability of the debris impacting the property, which accounts for the probability of vehicle failure and the location, size, and shape of the property (Requirement).

3.2.6.4 A range safety analysis shall establish launch/flight commit criteria (per paragraph 3.7.1 of this NPR) and operational constraints, such as hazard areas and impact limit lines, needed to control any risk due to debris impacts (Requirement).

3.2.6.5 A range safety analysis shall establish hazard areas needed to control risk due to debris including aircraft and ship hazard areas for notices to mariners and notices to airmen (Requirement).

### 3.2.7 Distant Focusing Overpressure Effects Risk Assessment.

3.2.7.1 A range safety analysis shall characterize the risk to the public and the workforce due to any distant focusing overpressure from potential explosions during vehicle operations for input to the risk management process (Requirement).

3.2.7.2 The analysis shall establish launch/flight commit criteria and operational constraints, such as hazard areas needed to control risk due to potential distant focus overpressure effects (Requirement).

3.2.7.3 A distant focusing overpressure analysis shall account for:

- a. The potential for distant focusing overpressure or overpressure enhancement given current meteorological conditions and terrain characteristics (Requirement).
- b. The potential for broken windows and related casualties (Requirement).
- c. Characteristics of the potentially affected windows, including their size, location, orientation, glazing material, and condition (Requirement).
- d. The hazard characteristics of the potential glass shards, such as falling from upper building stories or being propelled into or out of a shelter toward potentially occupied spaces (Requirement).
- e. The explosive capability of the vehicle at or after impact and at altitude and potential explosions resulting from debris impacts, including the potential for mixing and ignition of liquid propellants, ignition of flammable propellants, and other propellant hazards, pyrotechnic and other explosive devices, and pressurized vessels with the potential for high energy release (Requirement).



f. Characteristics of the vehicle flight and the surroundings that would affect the population's susceptibility to injury, for example, shelter types and time of day of the proposed activity (Requirement).

### 3.2.8 Toxic Hazard Risk Assessment.

3.2.8.1 In the case of a catastrophic failure of a vehicle in flight, the fire, explosion, reactivity, and safety hazards of propulsion and power fluids (e.g., hydrazines, nitrogen tetroxide, solid rocket motors fuels, and their combustion or decomposition products) may be released. Under certain meteorological conditions, high concentrations of these materials may drift over populated areas at levels greater than emergency health standards permit. As a result, NASA shall protect the public and workforce from toxic hazards using either hazard containment or a risk mitigation approach (Requirement). (For potential release of radioactive materials, see paragraph 3.4.)

3.2.8.2 A range safety analysis shall establish launch/flight commit criteria and operational constraints, such as hazard areas needed to control any risk due to potential toxic material release (Requirement).

a. The analysis shall assess any residual risk due to potential toxic material release not fully contained or mitigated for input to the program's risk management process (Requirement).

b. The analysis shall account for:

(1) Any foreseeable toxic material release during the proposed flight or in the event of a mishap (Requirement).

(2) Any operational constraints and emergency procedures that provide protection from toxic material release (Requirement).

(3) All populations potentially exposed to any toxic material release, including all members of the public and workforce on land and on any waterborne vessels and aircraft (Requirement).

(4) Potential emissions from both nominal range operations and catastrophic events to ensure response actions are designed to prevent or mitigate possible exposures (Requirement).

3.2.8.3 Centers and vehicle programs shall take actions to protect people when an airborne toxic material released in a nominal or aborted launch/flight may produce concentrations above applicable Federal and local response guidelines identified or established by the cognizant range safety organization (Requirement).

*Note: Sources of toxic material release response guidelines include: American Industrial Hygiene Association - Emergency Response Planning Guidelines (ERPG), Occupational Safety and Health Administration - Permissible Exposure Limit (PEL), American Conference of Government and Industrial Hygienists - Threshold Limit Value (TLV), and Environmental Protection Agency - Acute Emergency Guidance Level (AEGL).*

### 3.2.9 Containment.

3.2.9.1 When controlling risk through containment, the range safety analysis shall provide the basis for establishing the geographical areas from which people and any property identified under paragraph 3.2.4.3.b are to be excluded during flight (Requirement).

3.2.9.2 The analysis shall determine any operational controls needed to isolate each hazard and prevent/mitigate the risk due to the hazard (Requirement).

3.2.9.3 All cognizant range safety organizations, in conjunction with the program, shall establish the



containment criteria for normal and malfunctioning vehicle flight (Requirement).

3.2.9.4 Any residual risk due to any hazard not fully contained shall undergo the risk management process of paragraph 3.2.4 (Requirement).

#### 3.2.10 Risk Mitigation.

3.2.10.1 When controlling risk through mitigation, a range safety analysis shall establish the operational constraints that negate the risk or reduce it to a level that is acceptable with appropriate management approval (Requirement).

3.2.10.2 Any residual risk not fully mitigated shall undergo the risk management process of paragraph 3.2.4 (Requirement).

### 3.3 Range Safety Systems

#### 3.3.1 Flight Termination System (FTS).

3.3.1.1 Each vehicle program shall implement an FTS that is fully compliant with the requirements of this NPR unless the flight risks are controlled through other means of containment and/or risk mitigation per the policy and requirements of paragraphs 1.2.2, 3.2.9, and 3.2.10 of this NPR that are approved by the cognizant Center range safety organization or NASA Range Safety Manager (Requirement).

*Note: NPR 8705.2, Human-Rating Requirements for Space Systems, contains requirements that apply when a Range Safety Destruct System (i.e., a form of FTS) is used on any component of an inhabited vehicle. When designing future inhabited aerospace vehicles, the program should consider vehicle designs, operational characteristics, procedures, and controls that negate the need for an FTS; e.g., controllability and high reliability, fuels, materials, pressurized or explosive components, and trajectories for launch and entry that limit exposure of populations to hazards. Based on a case-by-case assessment, an inhabited vehicle might incorporate an FTS only on certain components and not on the inhabited portion of the vehicle. Vehicle programs should evaluate the need for an FTS to provide the ability to terminate thrust without destroying (i.e., exploding) the vehicle as a distinct action. This ability may be critical to support crew survivability and may allow for the establishment of termination criteria/rules that provide significant reductions in risk to people or property on the ground.*

3.3.1.2 An FTS shall satisfy the requirements of AFSPCMAN 91-710, Range Safety User Requirements Manual or RCC 319, Flight Termination Systems Commonality Standard (Requirement).

*Note: Under the grandfathering provisions of AFSPCMAN 91-710, some existing vehicle programs are governed by Eastern and Western Range (EWR) 127-1, Range Safety Requirements, which is the predecessor to AFSPCMAN 91-710. NASA accepts this grandfathering where applicable.*

3.3.1.3 When an FTS is used for a NASA or NASA-sponsored vehicle, the vehicle program shall implement a secure FTS in accordance with NPR 2810.1, Security of Information Technology (Requirement).

3.3.1.4 Criteria for activation of the FTS for uninhabited vehicles shall include conditions for when:

a. Valid data shows the vehicle violating a flight termination boundary, unless other documented mitigations are in effect (Requirement).

- b. Vehicle performance or location is unknown, the vehicle is capable of violating a flight termination boundary, and terminating flight would mitigate the risk (Requirement).
- c. There is a gross trajectory deviation or obvious erratic flight rendering the vehicle uncontrollable (Requirement).
- d. Other mission-specific conditions present rationale for additional criteria (Requirement).

3.3.1.5 When an inhabited vehicle or its launch systems require an FTS, the cognizant Center range safety organization or the NASA Range Safety Manager and the program shall coordinate to develop the flight termination activation criteria (Requirement). NPR 8705.2, Human-Rating Requirements for Space Systems, applies.

### 3.3.2 Autonomous Flight Safety System (AFSS).

*Note: Autonomous in this context is defined as events or actions which occur without ground-based intervention during flight and may include flight termination for range safety purposes. NASA continues to coordinate with the Air Force and other members of the national range community to further develop and implement AFSS for space launch and other range operations, to include development of related range safety requirements.*

3.3.2.1 AFSS may be used for NASA range operations where the implementation meets vehicle and operational constraints and the system is designed and qualified to standards approved by the cognizant Center range safety organization or the NASA Range Safety Manager.

3.3.2.2 For human spaceflight, the primary purpose and operational concept for any flight safety system, including AFSS, is to protect the public while maximizing the likelihood of crew survival. To assure crew safety, any AFSS concept employed shall provide failure tolerance to catastrophic events per NPR 8705.2, Human-Rating Requirements for Space Systems (Requirement). The design and implementation of a human-rated AFSS may be highly specific to the human spaceflight vehicle and may incorporate, or work in conjunction with, unique aspects of the vehicle systems as appropriate.

*Note: The Space Shuttle Program will use existing range safety tracking and ground-based command systems through program fly out.*

### 3.3.3 Recovery Systems and Contingency Management Systems (CMS).

3.3.3.1 A Recovery System or CMS may use a set of elements within the vehicle, including but not limited to, manual control or autonomous control. A Recovery System or CMS may also include elements that are independent of the vehicle.

3.3.3.2 A Recovery System or CMS may provide for deliberate termination of an errant/erratic vehicle's flight but shall not be considered an FTS unless the system meets the requirements of paragraph 3.3.1 of this NPR and the related tracking, telemetry, and command requirements of paragraphs 3.3.4.1, 3.3.5.4, and 3.3.6 of this NPR (Requirement).

3.3.3.3 A Recovery System or CMS that does not meet FTS requirements may be considered as risk mitigation and factor into the range safety risk assessment for the range operation where applicable.

3.3.3.4 Activation of a Recovery System or CMS shall not increase the risk to people or property (Requirement).

### 3.3.4 Vehicle Tracking.

3.3.4.1 For a vehicle that is flown with an FTS:

- a. The range safety systems used to support a flight termination decision shall include at least two sources of vehicle tracking data, where the two sources are independent of each other and at least one of the sources is independent of the vehicle guidance system (Requirement).
- b. The tracking data from each source shall be of sufficient quality to determine the vehicle's real-time position and instantaneous impact point throughout the period of time that the data is needed to support a flight termination decision (Requirement).

*Note: For orbital vehicles, this tracking time period includes launch through the time that tracking and command capability is needed to protect the public from hazards of vehicle flight. This tracking time period is throughout the mission for suborbital or aeronautical vehicles and upon entry through landing for entry vehicles. The tracking time period may consider operational constraints. For example, for a launch, the tracking may not be needed immediately at liftoff as long as it will be available prior to the earliest time that the vehicle could endanger people or property.*

3.3.4.2 For the flight of an uninhabited vehicle that is flown without an FTS, the range safety system shall include tracking or other data sources sufficient to determine the impact footprint of all vehicle components (Requirement).

*Note: Most ranges that support NASA missions have local vehicle tracking requirements that apply (e.g., Air Force range safety vehicle tracking requirements are outlined in Air Force Space Command Manual 91-710).*

### 3.3.5 Telemetry.

3.3.5.1 All data systems that provide information used to evaluate range safety requirements shall undergo validation to ensure operational readiness prior to initiating any phase of flight such as launch or entry (Requirement).

3.3.5.2 The range safety telemetry system shall provide continuous, accurate data during preflight operations and during flight (Requirement).

3.3.5.3 The vehicle program shall coordinate with all cognizant range safety organizations to identify the safety data required for each flight (Requirement).

3.3.5.4 For a vehicle that uses an FTS, the telemetry data shall include parameters that describe the health and status of the FTS and the vehicle needed to support a flight termination decision (Requirement). These parameters may include:

a. FTS:

- (1) Receiver signal strength, command, and pilot tone or check channel status.
  - (2) Safe/arm status.
  - (3) Battery voltage.
  - (4) Battery temperature.
- b. Navigation system parameters such as position, velocity, and acceleration.
- c. Guidance commands including nozzle deflections in the pitch and yaw axes.
- d. Vehicle attitude data including pitch, yaw, and roll angles and rates.
- e. Engine chamber pressures.

f. Indicators of separation and/or jettison events.

g. Global positioning system positional and velocity data, when used for range safety purposes.

*Note: Most ranges that support NASA missions have local telemetry requirements that apply (e.g., Air Force range safety telemetry requirements are outlined in Air Force Space Command Manual 91-710).*

### **3.3.6 FTS Command System.**

3.3.6.1 An FTS command system used to support missions that require an FTS shall incorporate fully redundant and independent command paths (Requirement).

3.3.6.2 An FTS command system shall undergo validation to ensure operational readiness prior to every mission (Requirement).

3.3.6.3 FTS command systems shall be under configuration control (Requirement).

## **3.4 Radiation Systems**

NASA Centers and programs with range operations that use radiation sources (e.g., radio-frequency/microwave emitters, radioactive materials, X-ray devices, lasers, and optical emitters) are subject to the requirements of NPR 1800.1, NASA Occupational Health Program Procedures, Chapter 4, and local range requirements. NPR 8715.3, NASA General Safety Program Requirements, Chapter 6, contains requirements and guidance applicable to space launch of radioactive materials.

## **3.5 Laser Hazard Controls**

NASA range operations involving the use of lasers are subject to the requirements of NPR 1800.1, Chapter 4, and local range requirements.

*Note: This includes required assessment and approval by NASA laser safety officials, coordination with the FAA for lasers entering the National Airspace, and coordination with the DoD Laser Safety Clearinghouse for lasers with the potential to strike orbiting satellites.*

## **3.6 Safety-Critical Software**

Vehicle programs and range safety organizations shall identify safety-critical software in range safety systems owned by NASA or used to support NASA missions and ensure it satisfies NPR 7150.2, NASA Software Engineering Requirements, and NASA STD 8719.13, Software Safety (Requirement).

## **3.7 Operational Requirements**

### **3.7.1 Launch/Flight Commit Criteria.**

3.7.1.1 The launch/flight commit criteria for a range operation shall identify the conditions required to initiate each flight or phase of flight (see paragraph 3.2.4.3.e.1 for requirements that apply to phases of flight) (Requirement).

### 3.7.1.2 The launch/flight commit criteria shall provide for:

- a. Assurance that the collision avoidance requirements of paragraph 3.7.3 are satisfied for any launch or entry (Requirement).
- b. Surveillance of any established hazard areas (Requirement).
- c. Verification that all range safety systems are available and operational (Requirement).
- d. Verification that the meteorological conditions, such as wind and visibility, are within the limits defined by the range safety analysis (Requirement).
- e. Verification that natural and triggered lightning constraints are within limits (requirement).
- f. Verification that the range safety risk criteria are satisfied including any specific range safety risk constraints (Requirement).

3.7.1.3 Implementation of the launch/flight commit criteria shall include documenting the actual conditions at the time of flight or time of each phase of flight where applicable to verify that the launch/flight commit criteria have been met (Requirement).

### 3.7.2 Entry Operations.

An entry operation that is primarily for mission purposes other than disposal begins with the final commitment to entry and landing (e.g., the final command that initiates or enables the entry and landing sequence or the final decision point to allow the entry to proceed) and ends when all vehicle components associated with the entry come to rest on the Earth (including any jettisoned components).

*Note: NPR 8715.6 contains requirements for limiting orbital debris generation, including requirements that apply to entry for the primary purpose of disposal, such as controlled or uncontrolled entry of spent launch vehicle upper stages after orbital insertion or orbital spacecraft that have completed their mission.*

3.7.2.1 Entry and landing shall not be committed until the vehicle program confirms that all conditions critical to safety are met (Requirement).

3.7.2.2 The entry phase of a vehicle program's risk management process, including the vehicle's reliability to achieve controlled entry to the targeted landing site or debris footprint, shall be approved by the cognizant Center range safety organization or the NASA Range Safety Manager prior to launch (Requirement).

*Note: The intent is to provide assurance that the vehicle will be deorbited in a predictable manner that allows for appropriate risk management for the entry operation in accordance with paragraph 3.2.4. of this NPR.*

### 3.7.3 Collision Avoidance (COLA).

3.7.3.1 During launch and entry operations, the space vehicle program, in coordination with all cognizant range safety organizations, shall ensure that the vehicle, any jettisoned component, and/or payload meets one of the following criteria with regard to all orbital inhabited or inhabitable spacecraft (Requirement):

- a. Spherical volumes greater than or equal to 200 kilometers; OR
- b. An ellipsoidal miss distance greater than or equal to 200 km in-track and 50 km cross-track or radially; OR



c. A probability of impact less than or equal to  $1 \times 10^{-6}$ .

*Note: A program or range organization may set additional criteria to protect against collision with other orbiting spacecraft or objects. These criteria may also be appropriate for use during on-orbit maneuvers. Example: NASA launches from an Air Force range are subject to Air Force Instruction 91-217, Space Safety and Mishap Prevention Program, which provides criteria for protection of active satellites in addition to inhabited/inhabitable spacecraft.*

3.7.3.2 The vehicle program designated range safety representative or cognizant range safety organization shall:

a. Inform the United States Strategic Command of an upcoming launch or entry operation at least 15 days before the operation (Requirement).

b. Notify the United States Strategic Command immediately of any change in the planned launch or entry operations that occurs after the initial notification (Requirement).

c. Obtain a COLA analysis from the United States Strategic Command or perform an equivalent analysis needed to satisfy paragraph 3.7.3.1 of this NPR (Requirement). The COLA analysis shall:

(1) Establish each wait in a planned launch/entry window during which the vehicle program will not initiate or commit to launch/entry in order to satisfy the criteria of paragraph 3.7.3.1 of this NPR and any program or range specific criteria (Requirement).

(2) Account for the vehicle, any jettisoned component, and/or payload achieving altitudes greater than 150 km (Requirement).

(3) Account for uncertainties associated with vehicle performance and timing and ensure that any calculated launch/entry waits incorporate all additional time periods associated with such uncertainties (Requirement).

(4) For an orbital launch, account for ascent to orbital insertion plus a number of revolutions that: (i) accounts for each objects' orbit type, (ii) accounts for each objects altitude in relation to each other as needed to satisfy the applicable criteria, and (iii) provides sufficient time for each new orbital object to be catalogued by United States Strategic Command (Requirement).

(5) For a suborbital launch, account for the entire flight to landing or final impact (Requirement).

*Note: The COLA analysis need not account for an inhabitable orbital object if the three-sigma maximum altitude capability of the launch vehicle, any jettisoned component, and/or payload is 50 km or more below the orbital perigee of the inhabitable object.*

(6) For an entry operation, account for the entry trajectory from the point that deorbit is committed through landing or final impact (Requirement).

d. Implement launch/entry waits as launch/flight commit criteria per paragraph 3.7.1 of this NPR and any other constraints needed to satisfy paragraph 3.7.3.1 of this NPR (Requirement).

3.7.4 Unmanned Aircraft Systems (UAS) Operations. NASA UAS operations are subject to the requirements of NPR 7900.3, Aircraft Operations Management, Chapter 5, and the applicable range safety requirements and methodologies of this NPR.

*Note: RCC 323, Range Safety Criteria for Unmanned Air Vehicles and RCC 555, User Guide for Unmanned Aerial System Operations on the National Ranges provide additional guidance for organizations hosting or sponsoring a UAS operation.*



**3.7.5 Aerostat/Balloon Systems Operations.** Each vehicle program involved in operating an aerostat or balloon (this includes hosting or sponsoring an aerostat or balloon operation) is subject to 14 CFR, 101: Aeronautics and Space, Part 101 - Moored Balloons, Kites, Unmanned Rockets and Unmanned Free Balloons.

*Note: Guidance for operating an aerostat or balloon in special use airspace can be found in Air Force Space Command Manual 91-710.*

## **3.8 Range Safety Personnel Qualifications and Training**

**3.8.1** Qualifications for personnel who perform a range safety function for a NASA range operation (including RSOs and personnel responsible for range safety systems and range safety analysis) shall include:

- a. Successful completion of knowledge-based training (self-study and/or classroom) applicable to the range safety function (Requirement).
- b. Successful completion of instructor-led, hands-on training on how to perform the range safety function followed by satisfactory on-the-job performance as a trainee, as applicable (Requirement).
- c. Proficiency demonstrated to a qualified range safety professional during simulation scenarios that exercise hands-on operations of range safety systems and use of safety decision-making tools or processes, as applicable (Requirement).
- d. Proficiency demonstrated to a qualified range safety professional during exercises of nominal and contingency actions, as applicable (Requirement).

**3.8.2** The training program for range safety personnel who support NASA range operations shall:

- a. Provide qualified personnel to support nominal and contingency range operations (Requirement).
- b. Include a recurring training process to ensure personnel retain their qualifications (Requirement).
- c. Include a requalification process for personnel who lose qualification status, such as someone who exhibits substandard performance or has health problems (Requirement).
- d. Include a documentation process that captures the qualification, recurring training, and requalification status of all range safety personnel (Requirement).

**3.8.3** RSOs with real-time safety decision-making responsibility (including FTS command responsibility) shall meet the safety certification requirements of NPR 8715.3, paragraph 7.4.6, in addition to the requirements of this NPR (Requirement).

*Note: NPR 8715.3, paragraph 7.4.5 lists RSOs under Hazardous Operations Requiring Safety Certification. Not all RSO functions involve real-time operations. The focus of the safety certification requirements in NPR 8715.3, paragraph 7.4.6 (including physical examination) is on RSOs with real-time safety decision-making responsibility.*

# Appendix A. Definitions

A.1 Casualty: An injury requiring overnight hospitalization or worse, including death. For the purpose of casualty modeling, any injury that, due to its severity, qualifies as a Level-3, 4, 5, or 6 injury per the Abbreviated Injury Scale (AIS), Association for the Advancement of Automotive Medicine, would be counted as a casualty.

A.2 Certificate of Authorization or Waiver: A Certificate of Authorization or Waiver constitutes relief by the FAA from specific regulations for the period of time specified on the certificate. The FAA will issue Certificates of Authorization or Waiver only to public (e.g., a university) or Government organizations. The Certificate of Authorization or Waiver will specify the operations that are permitted, define the area where the operations may be conducted, and specify altitudes at which they may be conducted.

A.3 Collective Risk: The total combined risk to all individuals exposed to one or more particular hazards during a specific period of time or event (a specific phase of flight). Unless otherwise noted, collective risk for a range operation is the mean number of casualties expected ( $E_c$ ) during an established period or event (e.g., a launch) due to the combination of all hazards associated with the operation.

A.4 Commercial Launch: A service supplied by the private sector that provides the capability of placing a vehicle and any payload into a suborbital trajectory, Earth orbit, or into outer space.

A.5 Containment: A range safety technique that precludes hazards from reaching the public, the workforce, or property that requires protection during normal and malfunctioning vehicle flight.

A.6 Contingency Management System: A system designed to manage the vehicle throughout the atmospheric flight envelope that provides a controlled response under the full set of circumstances defined by the mission's risk assessment. The system may be comprised of a set of elements within the vehicle, including but not limited to, manual control, autonomous control, and recovery capability.

A.7 Critical Operations Personnel: Critical Operations Personnel include persons not essential to the specific operation (launch, entry, flight) currently being conducted, but who are required to perform safety, security, or other critical tasks at the launch, landing, or flight facility. Critical Operations Personnel are notified of the hazardous operation and either trained in mitigation techniques or accompanied by a properly trained escort. Critical Operations Personnel do not include individuals in training for any job or individuals performing routine activities such as administrative, maintenance, or janitorial. Critical Operations Personnel may occupy safety clearance zones and hazardous areas and need not be evacuated with the public. Critical Operations Personnel are included in the same risk category as Mission Essential Personnel.

A.8 Emergency Response Planning Guidelines (ERPG) - Level 2: The ERPG - Level 2 is the maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual's ability to take protective action.

A.9 Entry Operation: The sequence of controlled thrust maneuvers or other events that brings a space vehicle or spacecraft from Earth orbit or outer space to Earth. Entry operations do not include suborbital flights.

A.10 Equivalent Level of Safety (ELS) (determination): The approval of an alternative approach to

satisfying a range safety requirement where the alternative provides an approximately equal level of safety as determined by qualitative or quantitative means (see paragraph 1.5 of this NPR).

A.11 Expectation of Casualty (Ec): The average number of casualties expected per an event, such as vehicle flight, if a large number of events could be carried out under identical circumstances.

A.12 Expendable Launch Vehicle: A vehicle that, once launched, is not reused and typically is not retrieved.

A.13 Explosive Debris: Solid propellant fragments or other pieces of a launch or entry vehicle or payload that result from breakup of the vehicle during flight and that explode upon impact with the Earth's surface or on their own and cause overpressure.

A.14 Flight: Launch or entry of an orbital or suborbital space vehicle/spacecraft or operation of an aeronautical vehicle. For the purposes of this NPR, "flight" does not include on-orbit operations.

A.15 Flight Termination System (FTS): A type of range safety system designed, tested, and incorporated into vehicles that provides for the independent and deliberate termination of an errant/erratic vehicle's flight.

A.16 FTS Command System: All components needed to send a flight termination command signal to an onboard vehicle flight termination system. An FTS command system starts with flight termination activation switches and ends at each command-transmitting antenna. It includes all intermediate equipment linkages, software, and auxiliary transmitters that ensure a command signal will reach the onboard vehicle flight termination system during flight.

A.17 Hazard: A state or condition that could potentially lead to an undesirable consequence (i.e., casualty or property damage).

A.18 Hazard Area: A defined region of land, water, or airspace within which hazards exist or have the potential to exist during a range operation such that the risks associated with the hazards may be mitigated by controlling access to the defined region.

A.19 Individual Risk: The probability of an individual from a certain group (or subgroup) at a specific location suffering a casualty from exposure to a given event during an established period (e.g., a launch). Individual risk is stated as a Probability of Casualty (Pc).

A.20 Landing Site: The location on which a vehicle impacts, lands, or is recovered.

A.21 Launch: To place a vehicle and any payload from Earth in a suborbital trajectory, in Earth orbit, or in outer space. For an orbital mission, launch begins with lift-off and ends with orbital insertion. For a suborbital mission, launch begins with lift-off and ends with landing/final impact of all vehicle components.

A.22 Launch Site: The location from which a launch takes place. This includes land, air, or a sea-based position.

A.23 Mishap: Any unplanned event or series of events that results in death, injury, occupational illness, or damage to or loss of property.

A.24 Mission Essential Personnel: Government or contractor personnel who are directly involved in ensuring the safety and success of a mission. For the purposes of range safety, mission essential personnel do not include any people on board the vehicle.

A.25 NASA Launch: A launch conducted by or for NASA, where NASA is so substantially involved that it effectively directs or controls the activity.

A.26 National Airspace System: The common network of U.S. airspace controlled by the FAA including air navigation facilities, equipment and services, airports or landing areas, aeronautical charts, information and services, rules, regulations, and procedures, technical information, and manpower and material. Also included are system components shared jointly with the military.

A.27 Orbital Insertion: With regard to the application of requirements and criteria in this NPR to a space launch, orbital insertion occurs when the vehicle or component achieves a minimum 70 nm perigee based on a computation that accounts for drag.

A.28 Payload: The object(s) within a payload fairing carried or delivered by a vehicle to a desired location or orbit.

A.29 Probability of Casualty (Pc): A measure of individual risk. Pc is the probability that an individual at a specific location would be a casualty per an event, such as vehicle flight, if a large number of events could be carried out under identical circumstances. For example, if an individual would be a casualty once per one million identical launches, the Pc for such a launch would be  $1 \times 10^{-6}$ .

A.30 Probability of Impact: The probability that one or more pieces of debris from a vehicle will impact a given location or object (e.g., aircraft, ships).

A.31 Property: In the context of this NPR, the term property is intended in the broadest sense. Property includes, but is not limited to public or privately owned land/real estate, homes, factories, livestock, natural resources, facilities, equipment, and other assets (including those on or off a range or launch or landing site). Local authorities and programs are responsible for identifying property that requires protection per paragraph 3.2.4.3.b of this NPR. In general, the range safety function to protect property does not include protection of the vehicle or payload being flown in a range operation.

A.32 Public: For the purposes of range safety risk management, all people who are not Critical Operations Personnel or Mission Essential Personnel. Public includes visitors and personnel inside and outside NASA-controlled locations who are not Critical Operations Personnel or Mission Essential Personnel and who may be on land, on waterborne vessels, or in aircraft.

A.33 Range: A permanent or temporary area or volume of land, sea, or airspace within or over which orbital, suborbital, or atmospheric vehicles are tested or flown. This includes the operation of launch vehicles from a launch site to orbital insertion or final landing or impact of suborbital vehicle components. This also includes the entry of space vehicles from the point that the commit to deorbit is initiated to the point of intact vehicle impact or landing or the impact of all associated debris. This includes range operations with aeronautical vehicles from takeoff to landing.

A.34 Range Operation: The flight of a launch or entry vehicle or experimental aeronautical vehicle including any payload, at, to, or from a range, launch site, or landing site. Range operations utilize specific infrastructure as well as trained and certified human interfaces to monitor, command, and control the range safety elements associated with programs. Range operations do not include the flight of conventional piloted aircraft unless specific aspects of the operation require range safety involvement to protect the public, workforce, and/or property. Range operations do not include on orbit operations of vehicles after orbital insertion or prior to initiation of entry.

A.35 Range Operator: A range operator is either a NASA, DoD, commercial, or foreign entity responsible for providing the ground, sea, air, or space-based assets required to support range operations.

A.36 Range Safety: Application of safety policies, principles, and techniques to protect the public,

workforce, and/or property from hazards associated with range operations.

A.37 Range Safety Officer (RSO): A person responsible for safety during a range operation. An RSO has the authority to hold or abort the operation, or take a risk mitigation action, which includes terminating the flight. RSO is synonymous with the term Mission Flight Control Officer used at some DoD ranges.

A.38 Range Safety Organization: An organization that reports to the safety authority for range operations, oversees the implementation of range safety requirements, and may provide range safety-related services and operational support to vehicle programs.

A.39 Range Flight Safety Program: A program implemented to ensure that the risk to the public, workforce, and property during range operations is effectively managed.

A.40 Range Safety System(s): A system (including any subsystem) whose performance is factored into the range safety analysis and relied upon during flight to mitigate hazards. These systems include range safety displays, range clearance capability, radar, optic tracking systems, telemetry, tracking display systems (including instantaneous impact predictors), contingency management systems, flight termination systems, and command and control capability for flight termination systems.

A.41 Range Safety Waiver: A written authorization allowing a range operation to continue even though a specific range safety requirement is not satisfied and the vehicle program is not able to demonstrate an equivalent level of safety. A Range Safety Waiver involves the formal acceptance of increased safety risk by appropriate authorities.

A.42 Range User: A range user is considered a flight test or launch and/or entry vehicle program that conducts range operations on a range.

A.43 Recovery System: A system that is installed on a flight test, launch, or entry vehicle that may be activated when the vehicle has malfunctioned and cannot be recovered under its own capacity. For example, the system may deploy a parachute, extend landing gear, or move flight control surfaces in the attempt to reduce the impact of the vehicle with the ground. Recovery systems are intended to preserve the vehicle and do not necessarily address range safety concerns.

A.44 Reusable Launch Vehicle: Experimental or operational space launch vehicle that is intended to be reused (at least in part).

A.45 Risk: The baseline definition for risk is the product of (1) the probability (qualitative or quantitative) that a program will experience an undesired event such as cost overrun, schedule slippage, safety mishap, or failure to achieve a needed technological breakthrough; and (2) the consequences, impact, or severity of the undesired event were it to occur. For range safety, risk is expressed as casualty expectation, which is a measure that takes into consideration both the probability of occurrence and the consequence of a hazard or combination of hazards to a population or installation. Risk is measured in the same units as the consequence, such as number of injuries, fatalities, or dollar loss.

A.46 Secure Flight Termination System: National Security Agency approved cryptography incorporated into the operations center and vehicle that provides a capability for the secure or authenticated transmissions of a flight termination command or the activation of the FTS.

A.47 Space Launch Vehicles: Operational or experimental vehicles that are launched into orbital or suborbital flights for the purpose of carrying payloads to and from space or demonstrating technologies to further access to space. These vehicles are either inhabited or uninhabited (i.e., ELV, Space Shuttle or equivalent) and may travel at speeds ranging from subsonic to hypersonic.



A.48 Tailoring: The process where the authorities responsible for range safety requirements and a range user review each requirement and jointly document whether the requirement is applicable to the range user's planned operations and, if it is applicable, document whether the range user will meet the requirement as written or achieve an equivalent level of safety through an acceptable alternative. Tailoring includes ELS determinations. Tailoring does not include the approval of Range Safety Waivers, which are addressed by a separate process.

A.49 Unmanned Aircraft Systems (UAS): A UAS includes an Unmanned Aerial Vehicle (UAV) or similar vehicle and all the associated support equipment, control station, data links, telemetry, communications and navigation equipment necessary to operate the vehicle

A.50 Unmanned Aerial Vehicle (UAV): A vehicle that is controlled remotely or that is autonomous and operates at speeds ranging from subsonic to hypersonic in a manner consistent with a "conventional" aircraft. A UAV may be launched from the ground or dropped from other aerial vehicles, subscale flight test vehicles, or lifting bodies. A UAV may also be referred to using a different name such as Uninhabited Air Vehicle, Unmanned Aircraft, Drone, Remotely Piloted Aircraft, Remotely Operated Aircraft, or Remotely Piloted Vehicle. Model aircraft (normally vehicles of less than 55 lbs gross weight flown under manual control within unaided visual contact range) when flown for nongovernmental, recreational purposes are not considered UAVs.

A.51 Workforce: Government or contractor personnel who are directly involved in a range operation or who work at a range, launch site, or landing site where a NASA range operation takes place. For the purposes of this NPR, "workforce" does not include any crew on board a vehicle during flight.

# Appendix B. Acronyms

AFSS	Autonomous Flight Safety System
AFSPCMAN	Air Force Space Command Manual
AIS	Abbreviated Injury Scale
CFR	Code of Federal Regulations
CMS	Contingency Management System
COA	Certificate of Authorization or Waiver
COLA	Collision Avoidance
DoD	Department of Defense
Ec	Expectation of Casualty
ELS	Equivalent Level of Safety
ELV	Expendable Launch Vehicle
ERPG	Emergency Response Planning Guidelines
EWR	Eastern and Western Range
FAA	Federal Aviation Administration
FTS	Flight Termination System
KSC	Kennedy Space Center
NASA	National Aeronautics and Space Administration
NASA STD	NASA Technical Standard
NPD	NASA Policy Directive
NPR	NASA Procedural Requirements
NSS	NASA Safety Standard
OSMA	Office of Safety and Mission Assurance
Pc	Probability of Casualty
RCC	Range Commanders Council
RLV	Reusable Launch Vehicle
RSO	Range Safety Officer
SMA	Safety and Mission Assurance

SRR	Systems Requirement Review
UAS	Unmanned Aircraft Systems
UAV	Unmanned Aerial Vehicle